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## Secular trends in stature of late 20th century white South Africans and two European populations

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### ABSTRACT

During the 20th century a general positive secular trend for stature is observed in developed countries around the world while shorter statures, often associated with a lack of a positive secular trend, have mostly been observed in populations with lower SES. The purpose of this study was to compare secular changes in stature between 20th century South Africans of European descent and two European populations. The comparative samples include Dutch males with which there is an assumed genetic relationship, and Swiss males for which the genetic association is less clear. The sample comprised anthropometric stature data of white South Africans (17–62 years), Swiss and Dutch males (18–21 years) obtained from military conscripts with birth cohorts of 5 years from 1946 to 1995. The stature of white South African males did not increase at a significant rate compared to those observed in Swiss and Dutch males. South African and Dutch males were of similar height following World War II, but a considerable trend was observed only in the Dutch group. The Swiss group was initially shorter than the South Africans, but due to a positive secular trend their average stature is on a par with that of South Africans in the most recent cohort. The lack of a significant positive secular trend in the South African group could suggest that factors such as gene flow and poor economic and social development in South Africa resulted in shorter statures in white South African groups than expected.

### Introduction

Temporal changes in certain aspects of the human body are known as secular trends. The direction and rate of secular trends are subject to change and may also be more pronounced in specific population groups (Henneberg and Van den Berg, 1990; Price et al., 1987; Roche, 1979; Tobias, 1985; Tobias and Netscher, 1977; Wolański, 1978). Secular trends could occur in response to variations in living conditions. It is commonly accepted that the direction and tempo of secular trends are a reflection of changes in the socio-economic situation in a country (Bogin, 1999; Rühli and Henneberg, 2013; Staub et al., 2011). Therefore, the direction and rate of secular trends of population groups usually correspond with the standard of living (e.g., GDP per capita, real wages, access to healthcare and other SES variables) within the country (Bogin, 1999; Bogin et al., 2017; Staub et al., 2011). For example, in countries with high standards of living, marked positive secular trends are expected.

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Most studies (e.g., Bogin, 1999; Bogin and Varela-Silva, 2010; Cole, 2003; Eveleth and Tanner, 1976; Federico, 2003; Komlos and Baur, 2004; Komlos and Lauderdale, 2007; Komlos, 2009; Staub et al., 2011; Steckel, 2009) on secular trends in stature across the globe have shown that there is a general trend towards an increase in stature. This can mostly be ascribed to increases in the lower limb length, especially the distal lower limbs (Eveleth and Tanner, 1976; Meadows and Jantz, 1995; NCD Risk Factor Collaboration, 2016). For example, using Dutch male conscript data, it has been shown that the mean height of males has increased from 1860 to 1990 (Cole, 2003). The positive secular trend observed in the Dutch conscripts continued into the 20th century and was even greater after the Second World War (WWII). However, this trend has only been taking place since the mid-19th century. During the 18th century, the mean average heights in many countries decreased due to poor harvests and high grain prices which resulted in poor nutrition during growth. Therefore, the increase in the 19th century is possibly a “correction” of the decreased statures observed in the 18th century (Cole, 2003; Floud et al., 1990; Hauspie et al., 1996; Komlos, 1985).

Bogin and Keep (1998) reviewed anthropometric data of individuals from Latin America and found that no secular trend occurred in stature from 1873 to 1989. Between 1898 and 1939 the mean stature decreased followed by an increase from 1940 to 1989. The authors explain that the negative secular trend is probably due to socio-economic factors such as poor health and nutrition during the latter period. The positive secular trend observed from 1940 may have been caused by world-wide economic recovery after WWII (Bogin and Keep, 1998; Bogin, 1999).

Hauspie and colleagues (1996,1997) have reviewed anthropometric data from children of various countries across the world (Europe and North America, Japan, Taiwan, Cuba, Brazil) as well as living adult stature of Eastern European countries. The same authors and also other researchers observed that, since World War II, a positive secular trend was visible in most Western and industrialized countries (Bogin, 1999; Cole, 2003; Hauspie et al., 1997). The secular increase in stature ranged between 3 mm/decade in Northern Europe (Sweden and Norway) to 30 mm/decade in parts of Southern and Eastern Europe. Countries with smaller rates of secular change in recent years, such as the Scandinavian countries and the Netherlands, appeared to be reaching a plateau of genetic potential for stature. Several other researchers have observed this slowdown in the height trend in recent years in Europe (Larnkjær et al., 2006; Schmidt et al., 1995; Staub et al., 2011) and North America (Komlos and Baur, 2004; Komlos and Lauderdale, 2007) which indicates that even with increased average income in a country, the population groups can only increase in height until the full genetic potential is reached. However, not enough data are currently available to determine whether the absence or slowing down of secular trends is short-term due to stabilization in the economy of the countries or whether the trends in stature will change in future due to possible changes in factors such as social inequality or inadequate health care and nutrition (Staub et al., 2011).

Numerous studies in countries with low SES such as India (Vogel, 1971), Peru (Frisancho et al., 1975), Guatemala (Bogin and MacVean, 1984), Mexico (Malina et al., 1980, 1983), Malawi, Kenya, Uganda, South Africa and South West Africa/Namibia (Burgess and Wheeler, 1970; Kark, 1954; Shaper and Saxton, 1969; Tobias, 1975a,b, 1992) have recorded evidence of negative secular trends. Developing countries often exhibit negative or null secular trends in stature. Studies from Guatemala and Venezuela have shown clear patterns of negative secular trends due to a civil war (Bogin and Keep, 1998). Children from all SES groups (high, moderate and low) exhibited a decline in stature as the quality of nutrition as well as the health of the entire population was affected (Bogin, 1999; Lopez-Blanco et al., 1995). Thus, the change in stature may have been more prominent in specific parts of the world while many developed countries have not experienced much secular change recently (Hermanussen et al., 2010; Larnkjær et al., 2006; Staub et al., 2011; Steyn and Smith, 2007).

In South Africa, negative, null and positive secular trends have been reported. Negative secular trends were observed in the stature and proximal lower limbs of black South African groups from the early 20th century (Kark, 1954; Price et al., 1987; Tobias and Netscher, 1977) while a positive secular trend was observed in the statures of Khoesan individuals (Tobias, 1990). Henneberg and Van den Berg (1990) and Louw and Henneberg (1997) observed small increases in the statures of black and white South African males.

Henneberg and Van den Berg (1990) measured the living stature of white adult South African groups born between 1880 and 1970. They found that the mean stature of white South Africans increased at a rate of 4.5 mm/decade during this period. Affluent white South Africans had a positive secular trend but did not significantly deviate from a straight line. Although white South Africans have had genetic influences from a variety of sources, there is a very strong link to the Dutch as the founder population and therefore it can be expected that the secular trend in stature may follow that of white individuals living in the Netherlands (15 mm/decade). However, the increase in stature of white South Africans was lower than expected. Overall, the reported secular increases were distinctly lower than those reported in Europe, indicating influences that are specific to South Africa (Henneberg and Van den Berg, 1990; Louw and Henneberg, 1997).

This study included medical students who could have been of higher SES than those represented by individuals from military conscript data. Therefore, the aim of this study was to evaluate and compare secular changes in stature of modern South African males of European descent to two modern European groups – a Swiss sample for which there is no clear genetic relationship and a Dutch group with which there is an assumed strong genetic relationship. Data from military sources were used. Additionally, stature data of white South African females were included to demonstrate the current secular changes taking place in white South African groups.

## Materials and methods

The data used in this study comprised the average heights of self-classified white South African soldiers from the South African National Defence Force (SANDF) collected by Ergotech (Ergonomics Technologies) which is an ergonomics consultancy company based in Pretoria, South Africa. The data were collected in the late 1980s, early 1990s, 2000 and 2013, and provide the opportunity

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